DOES TREE DENSITY OR FERTILISATION IN SILVOPASTORAL SYSTEMS AFFECT TREE OR PASTURE PRODUCTION?

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Abstract

Silvopastoral systems with high value timber trees are profitable due to the combination of long term high value timber tree production (over 4,000 € ha^{-1}) and the continuous meat production. Tree and pasture production depends on tree density and can be improved by the use of fertilisers, either organic or inorganic. Organic fertilisers, such as sewage sludge, can support agroforestry systems due to its high nutrient and organic matter contents if adequate doses are applied. This study aims at evaluating the effect of an initial sowing of pasture and plantation of two different tree densities fertilised with different types of organic fertilisers. Tree density did not affect tree growth probably due to the lack of competition at initial ages, being effective coppicing when frosts damaged the trees. Pasture production was improved by the different treatments depending on the limiting factor (fertility or water availability).

Keywords: sewage sludge, walnut, compost, pelletisation anaerobic digestion

Introduction

Sewage sludge (SS) has agronomic properties that make it suitable to use in agriculture as fertiliser as long as it is established before spreading and its heavy metal concentrations are below regulated limits (EU 1986). The main forms of stabilisation and processing the SS are aerobic digestion, anaerobic digestion and compost followed or not by pelletisation in the first two cases (Mosquera-Losada et al. 2010).

Silvopastoral practices and systems have great advantages as they increase biodiversity, enhance nutrient-use efficiency and increase carbon sequestration (Rigueiro-Rodríguez et al. 2009). Nevertheless, pasture production and tree growth may be affected, if adequate species are not used and if they are not planted in the right density for the farmer aims (Mosquera-Losada et al. 2011).We evaluated the tree growth and the productivity of a sown pasture in a *Junglans regia* L. silvopastoral system established in three treatments (open pasture (NT) and two tree densities 277 (LD) and 625 (HD) trees ha^{-1}) and fertilized with three differently stabilised SS (anaerobic, composted and pelletised) and two control treatments (no fertilisation and mineral fertilisation).

Materials and methods

This study was carried out in A Mota (Boimorto, A Coruña, Spain) on a plantation of *Juglans regia* L. managed by the Bosques Naturales company. In 2013, the plantation was established at low (LD: 277 trees ha^{-1}) and high tree density (HD: 625 trees ha^{-1}) and the plot was sown with *Dactylis glomerata* L., *Lolium perenne* L. and *Trifolium repens* L.

The experimental design was randomized blocks, with three replicates and five fertilisation treatments per each tree density which consisted of no fertilisation (NF), mineral fertilisation (MIN) with 500 kg of 8% N – 24% P_2O_5 – 16% K_2O ha^{-1} and fertilisation with anaerobic (ANA), composted (COM) and pelletised (PEL) SS (320 kg total N ha^{-1}) applied before tree planting. Mineral fertiliser was also applied in 2015, 2016 and 2017. The plots were grazed by sheep in a continuous stocking system.

Tree height was estimated with a measuring tape in April and December 2013, in January 2015 and in March 2016. Pasture production was determined by taking several samples of pasture per plot within an exclusion cage of 1 m^2 from 2014 to 2017. The samples were weighed in fresh in the field and a sub-sample was taken to the laboratory, weighed and dried (48 hours at 60ºC) and weighed again to determine the dry matter production. Pasture production was calculated without discounting the area occupied by the trees (NT) and taking into the area occupied by the trees established at high (HD) and low density (LD).

The data were analysed using ANOVA (proc glm procedure). Means were separated by using LSD test if ANOVA was significant (SAS 2001).

Results and discussion

Tree height was significantly affected by the year ($p<0.001$) and by the interaction year*tree density ($p<0.01$). Nevertheless, there were no significant differences between tree densities because the wide spacing used in these agroforestry systems allows trees to grow up without competition among them after plantation (Cabanettes et al. 1998).

Under each tree density, there were significant differences among years ($p<0.001$), mainly explained by the coppicing made in April 2014, but with a rapid recover of tree height in the following years (Figure 1) probably due to the already well developed root system in the soil after cutting. Walnut coppicing could be a good technique when frost damages trees after establishment.

Figure 1: Tree height in each tree density during the study period. Different letters indicate significant differences between dates within each tree density.

Pasture production obtained under NT and LD treatments was similar in all evaluated harvests (Figure 2) with the exception of those happened at the beginning of the study, and when the meteorological conditions where improved (May 2015) ($p<0.05$). This could be explained by the initial better pasture establishment of those plots developed on open sites and with low tree density. Pasture production was always higher under NT compared with HD treatment, which could be explained because the reduction of pasture area was small (1 part for tree out of 6 parts of land use) and compensated by the heterogeneity of the land. .

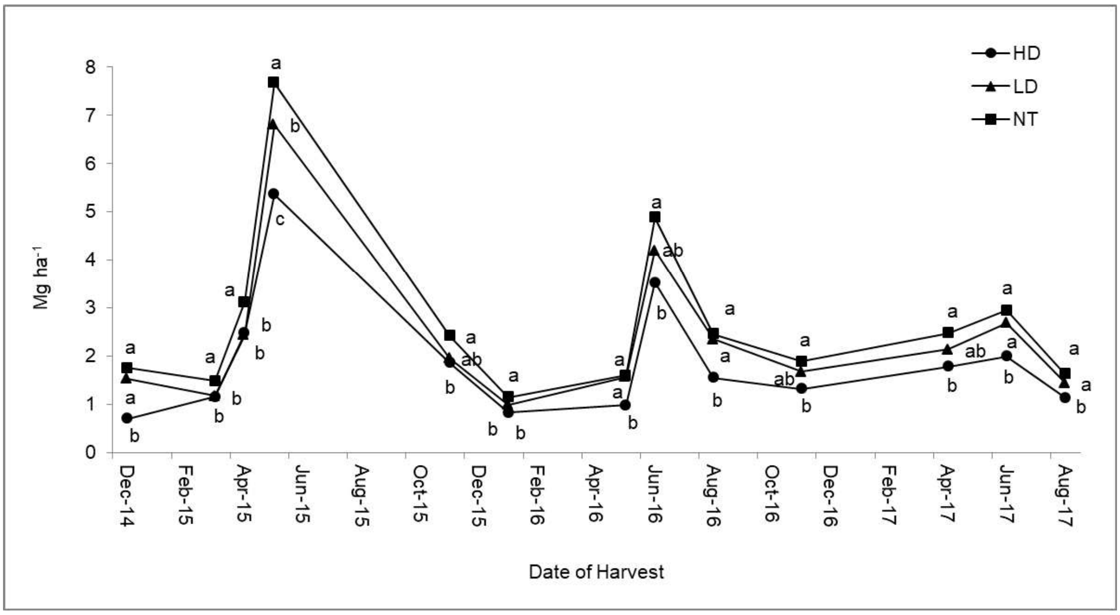

Figure 2: Pasture production (Mg dry matter ha^{-1}) in all treatments under open area (NT), low tree density (LD) and high tree density (HD). Different letters indicate significant differences between tree densities in each harvest.

Pasture production was modified by weather conditions, the long dry period in 2016 and the exceptional duration of the drought period happened during 2017 reduced significantly the production as the time came through. The reduction of the residual effect of fertilisation also explained the lower production of 2017 compared with 2016 and 2015. Pasture production of this study was similar to pasture production estimated by Mosquera-Losada et al. (2011) in a similar area.

When the mean pasture production in each treatment was considered, only April 2015, November 2015 and May 2016 had significant differences between treatments ($p<0.05$) (Figure 3). In April 2015, pasture production was higher in COM than in NF, ANA and PEL probably because COM implies higher inputs of organic matter that may reduce the negative effect of drought (Mosquera-Losada et al. 2010). However, in November 2015 NF plots had a higher production due to the higher pasture density and vascular plants biodiversity. Finally, in May 2016, pasture production was increased by PEL SS inputs compared with the other treatments, probably because PEL was applied every year and nitrogen was not leached (Mosquera-Losada et al. 2010).

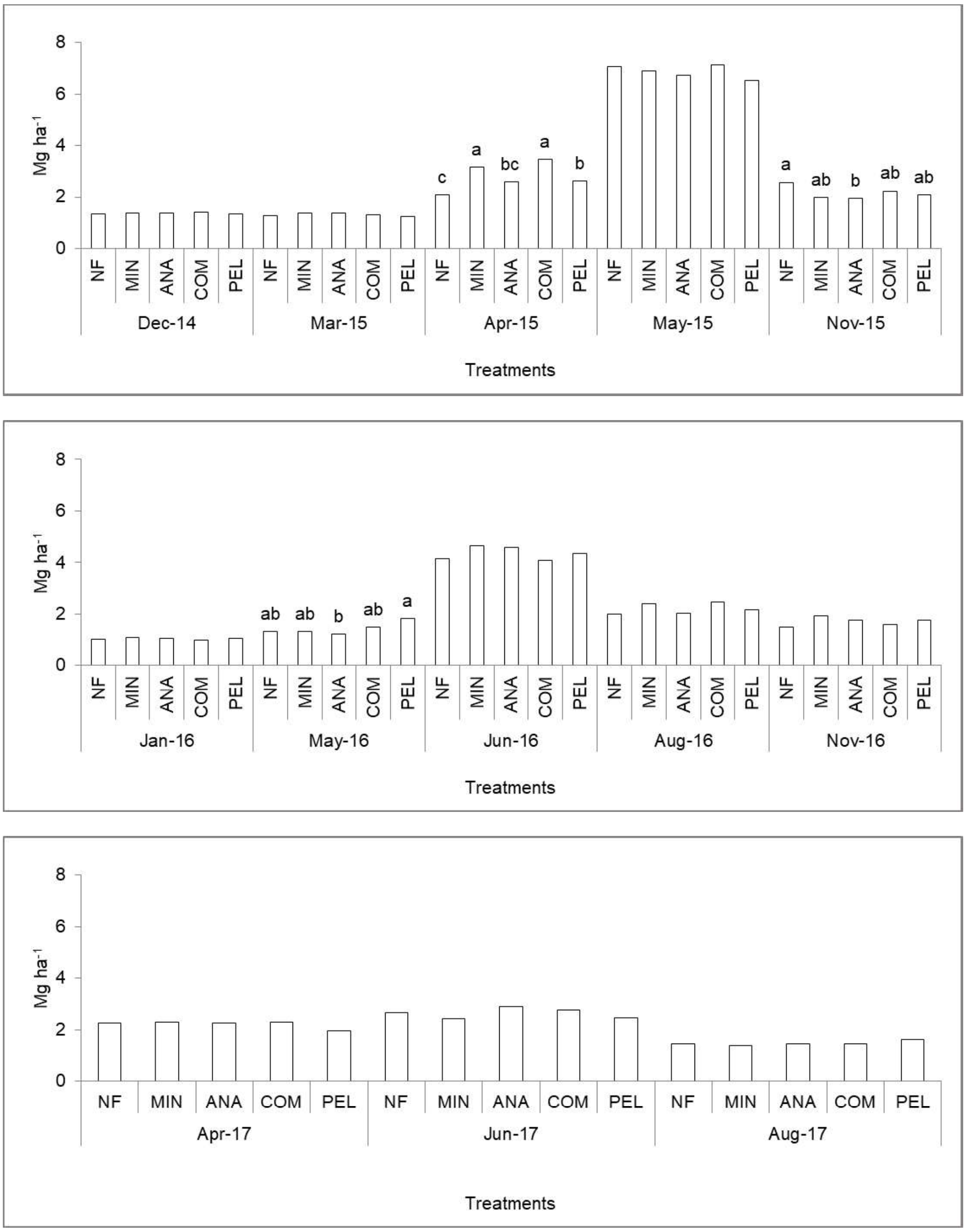

Figure 3: Mean pasture production (Mg dry matter ha^{-1}) in each treatment and in all harvests. NF: no fertilisation, MIN: mineral; ANA: anaerobic sludge; COM: composted sludge and PEL: pelletised sludge. Different letters indicate significant differences between fertiliser treatments in each harvest.

Conclusion

Walnut tree growth was not affected in young plantations, being effective coppicing when frosts damaged the trees. Pasture production was improved by the different treatments depending on the limiting factor (fertility or water availability). When the area occupied by the trees is discounted, pasture production was not affected by trees planted at low density at young ages, but the amount of land discounted with high density reduced pasture production.

The limitation of 100 trees per hectare in Regulation 640/2014 (EU 2014) should consider the age of the trees and be referred to mature trees, as no pasture production reduction was found when density is over 200 trees per hectare, in spite of discounting one out six parts of the territory to estimate production.

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